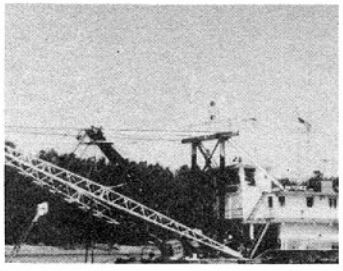
US Army Corps of Engineers



ENVIRONMENTAL LABORATORY

DREDGING OPERATIONS TECHNICAL SUPPORT PROGRAM

MISCELLANEOUS PAPER D-90-2

UPDATE OF THE CORPS' ENVIRONMENTAL EFFECTS OF DREDGING PROGRAMS (FY 89)

by

Robert M. Engler, Thomas R. Patin, Russell F. Theriot

Environmental Laboratory

DEPARTMENT OF THE ARMY
Waterways Experiment Station, Corps of Engineers
3909 Halls Ferry Road, Vicksburg, Mississippi 39180-6199

U.S. ARMY ENGINEER WATERWAYS EXPERIMENT STATION

February 1990
Final Report

Prepared for DEPARTMENT OF THE ARMY
US Army Corps of Engineers
Washington, DC 20314-1000

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

1a. REPORT SECURITY CLASSIFICATION: Unclassified	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT: Approved for public release; distribution unlimited.
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S): Miscellaneous Paper D-90-2	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION: USAEWES Environmental Laboratory; 6b. OFFICE SYMBOL (If applicable)	7a. NAME OF MONITORING ORGANIZATION
6c. ADDRESS (City, State, and ZIP Code): 3909 Halls Ferry Road, Vicksburg, MS 39180-6199	7b. ADDRESS (City, State, and ZIP Code)
8a. NAME OF FUNDING/SPONSORING ORGANIZATION: US Army Corps of Engineers; 8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS (City, State, and ZIP Code): Washington, DC 20314-1000	10. SOURCE OF FUNDING NUMBERS: PROGRAM ELEMENT NO. / PROJECT NO. / TASK NO. / WORK UNIT ACCESSION NO.

11. TITLE (Include Security Classification)
Update of the Corps' Environmental Effects of Dredging Programs (FY 89)

12. PERSONAL AUTHOR(S)
Engler, Robert M.; Patin, Thomas R.; Theriot, Russell F.

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year Month, Day)	15. PAGE COUNT
Final report	FROM _____ TO _____	February 1990	32

16. SUPPLEMENTARY NOTATION
Available from National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	Dredged material disposal Dredging Environmental effects

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

This report presents a broad program-level overview and documentation of the FY 89 activities of the Environmental Effects of Dredging Programs. The current thrusts of the programs are field assistance through the Dredging Operations Technical Support (DOTS) Program technical assistance aspects, research through the Wetlands Research Program and the Long-term Effects of Dredging Operations Program, and field verification/demonstration through the DOTS dredged material management aspects. These programs comprise the majority of the studies involved in evaluating the environmental effects of dredging and dredged material disposal.

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT	21. ABSTRACT SECURITY CLASSIFICATION	
☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS	Unclassified	
22a. NAME OF RESPONSIBLE INDIVIDUAL	22b. TELEPHONE (Include Area Code)	22c. OFFICE SYMBOL

DD Form 1473, JUN 86 *Previous editions are obsolete.* SECURITY CLASSIFICATION OF THIS PAGE

Unclassified

Preface

This report summarizes the activities of the Environmental Effects of Dredging Programs (EEDP) during FY 89. During the period, the EEDP was responsible for direct management of the Dredging Operations Technical Support (DOTS) Program, the Long-Term Effects of Dredging Operations (LEDO) Program, the Wetlands Research Program (WRP), and publication of the final reports for the Field Verification Program (FVP). Funding for development of this document was provided by the US Army Corps of Engineers DOTS Program. The DOTS Program is sponsored by Headquarters, US Army Corps of Engineers, and is assigned to the US Army Engineer Waterways Experiment Station (WES) under the purview of the Environmental Laboratory's (EL) EEDP.

The report was prepared by Dr. Robert M. Engler, Mr. Thomas R. Patin, and Mr. Russell F. Theriot of the Program Managers' Office of the EL. The writers are grateful to Dr. Michael Palermo of the Environmental Engineering Division, EL, and Dr. Richard Lee of the Ecosystem Research and Simulation Division, EL, for their efforts in reviewing the original manuscript. The report was edited by Mr. Robert Baylot, Jr., of the Visual Production Center, Information Technology Laboratory, but assigned to the Environmental Information Analysis Center (EIAC), EL.

This report was compiled under the general supervision of Dr. John Harrison, Chief, EL. Dr. Robert M. Engler was Manager, EEDP; Mr. Thomas R. Patin was assistant to the manager (EEDP) and the DOTS Coordinator, and Mr. Russell F. Theriot was Assistant Program Manager and coordinator for the LEDO and WRP.

The Commander and Director of WES is COL Larry B. Fulton, EN. Dr. Robert W. Whalin is Technical Director.

This report should be cited as follows:

Engler, Robert M., Patin, Thomas R., and Theriot, Russell F. 1990. "Update of the Corps' Environmental Effects of Dredging Programs (FY 89)," Miscellaneous Paper D-90-2, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Contents

Introduction

1. Before the early 1970s, there was limited knowledge of the environmental effects of dredging and dredged material placement. Consequently, there was little sound technical or scientific basis for regulating and managing the disposal of dredged material, and when regulations were available, they were often excessive, counterproductive, and without a technical basis. This problem was recognized by the Congress of the United States, and the US Army Corps of Engineers, pursuant to Public Law 91-611, was directed to conduct a comprehensive research program on dredged material placement. The Dredged Material Research Program (DMRP), which was conducted from 1973-1978, subsequently developed first-generation procedures for determining the environmental consequences of dredged material placement and developed new or improved methods for minimizing adverse effects.

2. The Corps was given the lead responsibility for conducting the research since the Corps is responsible for maintaining over 25,000 miles (40,000 km) of Federal channels and over 400 harbors involving the annual disposal of 250 to 300 million cubic yards (191 to 229 million cubic metres) of dredged material. In addition, the Corps regulates the discharge of dredged and fill material in waters of the United States including ocean waters involving an additional 150-200 million cubic yards annually. Approximately 14,000 dredging-related permit applications are processed annually by the Corps. Although the Corps is responsible for and regulates dredged material placement, the regulations are based on environmental guidelines and criteria developed jointly by the Corps and the US Environmental Protection Agency (USEPA). Therefore, results of the DMRP and other programs described in this report are the major technical base from which the regulations and implementation guidance were developed.

3. This report describes the major completed and ongoing programs (1973 to the present) addressing environmental effects of dredging, disposal, and/or fill activities. These are:

a. Dredged Material Research Program (DMRP).

b. Field Verification Program (FVP).

c. Dredging Operations Technical Support (DOTS) Program.

d. Long-Term Effects of Dredging Operations (LEDO) Program.

e. Wetlands Research Program (WRP).

f. Dredging Contaminated Sediment Work Unit of the Improvement of Operations and Maintenance Techniques (IOMT) Program.

All of these programs are research, field demonstrations, or technology transfer efforts of the Environmental Laboratory (EL) of the US Army Engineer Waterways Experiment Station (WES), Vicksburg, MS. Work is accomplished using contractual and in-house research and development capabilities. Through these and other programs the EL has evolved into an internationally recognized center of excellence for applied research, direct field assistance, and technology transfer programs on the environmental consequences of dredging and dredged material disposal. All current research and programs are under the centralized management of the Environmental Effects of Dredging Programs (EEDP). The majority of publications developed in the above programs are listed in Appendix A.

Completed Research

Dredged Material Research Program (1973-1978)

4. The Corps initiated the DMRP in 1973 and successfully completed the program in 1978 at a cost approaching $33 million. The DMRP was designed to be applicable nationally, including all major types of dredging activities, regions of the country, and environmental settings. The program resulted in first-generation procedures for evaluating the physical, chemical, and biological impacts for a variety of disposal alternatives in water, on land, and in wetland areas. It produced tested, cost-effective methods and guidelines for assessing and minimizing the impacts of conventional disposal alternatives. At the same time, the DMRP demonstrated the viability and limits of new disposal alternatives, including the beneficial use of dredged material as a natural resource. New or improved procedures were developed for designing, constructing, and managing confined disposal areas to maximize service life and minimize adverse environmental impacts. Procedures were developed to predict and minimize turbidity from dredged material disposal operations. Methods were developed to predict movement of dredged material in aquatic

environments. Guidance for creating habitat (such as wetlands) using dredged material was developed.

5. In addition to providing data and information needed to develop criteria and guidelines, two fundamental disposal management conclusions were reached. Studies conducted and experience gained in the post-DMRP years have supported these conclusions. The first conclusion is that no single placement alternative is most suited for a region or a type of project. Conversely, there is no single placement alternative that can be dismissed as environmentally unsatisfactory due to potential impacts. In other words, from a technical standpoint there is no inherent effect or characteristic of an alternative placement method that precludes its consideration before specific site assessment. This conclusion holds true for ocean placement, confined placement, or any other alternative.

6. The second fundamental conclusion relates to long-term management strategy. To address a variety of environmental factors and considerations adequately, long-term regional strategies are required for effective placement of dredged material. Through use of disposal management plans that consider project types, dredged material characteristics, placement alternatives, and other factors, the best opportunity exists for maximum environmental protection at an acceptable cost.

7. In summary, the results of the DMRP provided the first definitive information on the impacts of dredged material placement and on methods to minimize any adverse effects. This technology was made available to the users in the form of technical reports and synthesis reports. Over 250 technical reports were published on program results. The DMRP is summarized in an Executive document and annotated in a Publication Index and Retrieval System document as listed below.

Saucier, R. T., et al. 1978. "Executive Overview and Detailed Summary," Technical Report DS-78-22, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Herner and Company. 1978. "Publication Index and Retrieval System," Technical Report DS-78-23, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Field Verification Program (1981-1987)

8. During planning of LEDO field investigations with the Corps' New England Division, it became apparent that a unique set of circumstances existed in the New England region. The environmental effects of placement of highly contaminated dredged material from a single location could be evaluated simultaneously under three placement alternatives (open-water placement, upland placement, and wetland creation). The FVP was established as a cooperative effort among the Corps' New England Division, the WES, and the USEPA to field verify existing predictive laboratory testing procedures. It was a 6-year, $7.2 million program completed in FY 87. Through the program, promising procedures already developed by the Corps along with techniques previously developed by USEPA for other waste materials were applied to project conditions at Black Rock Harbor, Bridgeport, CT, using dredged material from a single highly contaminated maintenance dredging operation. Although the three placement alternatives were evaluated independently during the DMRP, the FVP investigations provided the first opportunity for direct comparison of the environmental consequences of placing the same dredged material under such a broad range of disposal conditions.

9. The program's major areas of investigation included:

a. Bioaccumulation of contaminants by aquatic animals. Levels of bioaccumulation of selected contaminants over time, biological and physical factors affecting bioaccumulation, and variability of bioaccumulation predictions were documented in the laboratory. Bioaccumulation was then determined under field conditions and compared with laboratory predictions to verify the accuracy of the prediction methods.

b. Consequences of bioaccumulation in aquatic animals. Physiological indices of biological health were assessed in organisms that have accumulated contaminants from dredged material. These indices, previously developed by USEPA for use in nondredged material regulatory programs, included scope for growth, sister chromatid exchange, reproductive effects, effects on enzyme systems, and histopathological parameters. The responses of aquatic animals to contaminants were determined in the laboratory to establish feasibility for assessing dredged material and correlation with bioaccumulation. Responses were then investigated in aquatic organisms exposed to contaminated sediments in the field.

c. Effects of aquatic placement on community structures. Effects of contaminated dredged material disposal on community structures were determined by measuring mortality, reproduction, and intrinsic rate of growth in selected populations within aquatic

communities. These assessments were documented in the laboratory and investigated in the field for verification purposes.

d. Effects of upland placement on water quality. Laboratory tests for predicting effluent quality were conducted on contaminated sediment before placement in a confined disposal area. The confined disposal area was designed, constructed, operated, and managed to ensure optimum fill configuration for the field studies and evaluation of effluent quality effects. During the filling operation, influent and effluent water quality parameters were monitored extensively at selected stations within the disposal area. Monitoring wells were placed around and within the disposal area, and ground-water samples were taken before, during, and after filling. Surface runoff water quality was predicted using laboratory rainfall runoff simulations. Following placement, the quality of rainfall-induced surface runoff water was determined by collecting surface water samples from controlled field rainfall simulation tests.

e. Bioaccumulation of contaminants in upland and wetland plants. Results of first-generation laboratory/greenhouse test procedures from DOTS and other studies were evaluated at the field site. Saltmarsh plants were grown in the laboratory under controlled wetland and upland conditions and analyzed for contaminant bioaccumulation. Field investigations were conducted to verify laboratory test results. Saltmarsh plants were planted at the upland disposal facility at Black Rock Harbor and sampled each growing season to determine contaminant bioaccumulation.

f. Bioaccumulation of contaminants in upland and wetland animals. Existing upland and wetland animal bioassay test procedures developed in Europe were conducted in the laboratory. Laboratory results were evaluated in the field using selected upland and wetland animals.

10. Results showed that laboratory methods for predicting effluent and surface water quality and plant toxicity in upland disposal sites compared well with field data results. The techniques for predicting effluent and surface water quality were shown to have good utility for predisposal evaluations of dredged material proposed for upland disposal. Methods for testing toxicity and bioaccumulation in plants in the wetland environment showed good predictive ability. However, optimum utility for predictive evaluations for the animal bioassays awaits further confirmation of their reproducibility. Techniques shown to have good utility for predisposal evaluation of dredged material proposed for aquatic disposal include toxicity, bioaccumulation, intrinsic rate of population increase, and scope for growth.

11. More methods for testing chronic, sublethal effects were evaluated in the aquatic environment than in the upland or wetland environments. Methods for predicting aquatic impacts were shown to have good utility for predisposal evaluations. In general, the effects of aquatic placement predicted in the laboratory and observed in the field were less persistent than in the other two environments. Wetland creation showed greater effects than aquatic disposal. Upland disposal produced the greatest and most persistent impacts. This is compatible with expectations based on the physicochemical behavior of contaminated dredged material in the three environments. The same ranking of effects in the upland, wetland, and aquatic environments can be expected in similar situations, although the relative magnitude of effects may be different.

12. The four primary synthesis documents produced by the program are listed below while all other documents produced are listed in Appendix A.

Folsom, B. L., Jr., et al. 1988. "Synthesis of the Results of the Field Verification Program Upland Disposal Alternative," Technical Report D-88-7, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Gentile, J. H., et al. 1988. "Applicability and Field Verification of Predictive Methodologies for Aquatic Dredged Material Disposal," Technical Report D-88-5, prepared by the US Environmental Protection Agency, Narragansett, RI, for the US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Simmers, J. W., et al. "Synthesis of the Results of the Field Verification Program Wetland Disposal Alternative," Technical Report (in preparation), US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Peddicord, R. K. 1988. "Summary of the U.S. Army Corps of Engineers/ U.S. Environmental Agency Field Verification Program," Technical Report D-88-6, Battelle Ocean Sciences, Duxbury, MA, prepared for Environmental Laboratory, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Direct Field Assistance Program--Dredging Operations Technical Support Program

13. The Corps established the Dredging Operations Technical Support Program in 1978 as a direct field assistance and technology transfer vehicle to assist the field in implementing the DMRP and subsequent research results. Direct assistance and consultation are provided, through DOTS, to all elements of the Corps (Districts, Divisions, and Headquarters) to handle environmental

problems associated with dredging and dredged material placement. Since DOTS was begun in 1978, over 1,450 requests for assistance from Corps operating elements have been acted upon. DOTS assistance includes briefings and seminars, study plans and project monitoring strategies, guidelines and criteria (federal, state, and local), technical review of reports, management plans for disposal areas, litigation, and other assistance.

14. The DOTS program has evolved in the past decade from a follow-up to the DMRP to a complete dredged material management strategy. The specific management tasks address high-priority technology application needs of the field as determined from direct field input. As the management tasks become a routine part of field application, the Corps continues to face new disposal management decisions brought on by even more environmentally complex problems, regulations, and changing national and international waste management policies. Based on these changing field needs, recommendations from the Chief of Engineers' Environmental Advisory Board, directions from HQUSACE, and direct request from the field, a complete Dredged Material Management structure for the DOTS Program is developed that will ensure appropriate technology transfer and technical application. These tasks are generally two-year efforts that package practical field guidance of existing technology as opposed to research efforts concerned with developing the technology. Additionally, these tasks will integrate ongoing case studies, field demonstrations, field strategy meetings, the LEDO Research Program, the FVP, the Environmental Impact Research Program, the WRP, and DOTS technology responses into field-tested management strategies for economically and environmentally sound management of dredged material.

15. The objectives are twofold: (a) to continue to address high-priority technology application needs of the field and (b) to apply a comprehensive long-term management strategy for the evaluation and assessment of multimedia placement of dredged material.

16. The following eleven high-priority field-directed technology needs are underway at this time within the Dredged Material Management aspects of the DOTS Program.

a. Automated Dredging and Disposal Alternative Management System (ADDAMS) (FY 87-90). ADDAMS provides the field with tools for designing, evaluating and managing site-specific and areawide dredged material disposal alternatives. It is a collection of user-friendly personal computer programs and models operating

under a single shell. ADDAMS presently incorporates programs for six management/design/evaluation techniques: solids retention and storage analysis for confined disposal facility design; analysis of consolidation and desiccation of dredged material for long-term storage requirements; hydraulic efficiency analysis for determination of retention time of confined disposal facilities; analysis of modified elutriate test results for chemical effluent quality prediction and mixing requirements; economic optimization analysis for site acquisition, use, and management and equipment selection; and prediction of short-term deposition and dispersion of dredged material disposed in open water. Additional techniques and methods are being incorporated into ADDAMS as well as improvements to the existing programs.

b. Guidelines for biological and physical monitoring of aquatic disposal (FY 87-89). Although monitoring of aquatic disposal sites is mandated in the Marine Protection Research and Sanctuaries Act, no standardized approach or method exists for Corps field elements to accomplish the mission. This task is concerned with developing those standardized approaches and methods to meet environmental requirements within cost constraints imposed on the project. The guidelines will be developed by integrating present knowledge about existing capabilities, tools, and techniques, and the results of field tests and experience. Options will be presented on a tiered basis and will cover a range of possible plans, from minimum requirements to an intensive, state-of-the art monitoring scenario for problem dredged material. Guidance will reflect the financial and time limitations resulting from such monitoring plans.

c. Beneficial uses of dredged material: applications in coastal open-water habitats (FY 88-90). Placement of dredged material to achieve wetland and upland wildlife benefits is gradually becoming acknowledged and practiced as a viable disposal management option. Open-water placement, however, is reluctantly tolerated by Federal and state fishery resource management agencies as a viable option only when all other alternatives are not available. However, evidence supports aquatic habitat enhancement through the placement of dredged material. This task is evaluating dredged material placement options in shallow and deep coastal open-water settings that will yield enhanced fishery habitat as well as potential dredging project cost savings. General aquatic habitat enhancement will be investigated through workgroups, while some field information will be obtained through observing ongoing District projects. For example, the Baltimore District (NAB) dredged material oyster beds and eelgrass habitat development sites are being monitored. These data will be supplemented with fishery resource information from the New England Division (NED) Disposal Area Monitoring System (DAMOS) Program as well as the Mobile District stable and near-shore berm projects. Interim

field reports are available and final offshore and inshore summary reports are due in September 1990.

d. Seasonal restrictions on dredging (FY 87-89). Operations and maintenance dredging in every District is affected in some way by seasonal dredging restrictions designed to protect significant biological resources. Districts comply with these restrictions, but in some instances the restrictions complicate scheduling, funding, and contracting, contributing to higher project costs and increased safety hazards of field operations. Ironically, little technical evidence supports many of these restrictions. This task is examining the applicability, necessity, and scope of restrictions for all aspects of dredging and dredged material placement. Criteria will be developed that could be used for applying restrictions where a technical information base is adequate. Some of the key coastal issues examined are: (1) entrainment of oyster larvae during hydraulic dredging, (2) dredge-induced turbidity effects on east and west coast anadromous fish migration, (3) impacts of barge and hopper overflow, and (4) dredge-induced reduction in dissolved oxygen. In addition a workshop assessing dredging restrictions in inland waterways will be conducted. Issue resolution guidance will be available in September 1990.

e. Optimization of dredging and dredged material disposal (FY 87-89). The objective of this task is to quantify the fiscal benefits obtainable by use of appropriate and intensive operation and management of confined disposal facilities, to develop generally applicable design guidance for small projects for which significant testing and design efforts are not warranted, and to address the optimization of the engineering aspects of other dredging and disposal technology. The task involves field demonstrations to refine procedures for designing, operating, and managing dredged material containment areas to meet required effluent suspended-solids standards and to provide adequate storage volume. Field site measurements are used to refine various predictive methods for volumetric sizing, estimating hydraulic efficiency, and predicting long-term storage capacity of containment areas. Definitive guidance has also been developed for predicting the dewatering potential of upland contained sites. Additional guidance will be available on trenching technology for dewatering, design guidance for small projects, and economic justification guidance for the various levels of management options available for upland disposal areas. The levels of management options may range from no activity at the site after disposal to intensive progressive trenching and crust removal to increase a site's useful disposal life.

f. Decisionmaking framework application software (FY 89-90). General implementation of the regulatory decisionmaking framework for management of dredged material is somewhat restricted because expertise in numerous fields is required by users.

Successful implementation of the strategy has invariably required the active participation of several technical personnel. This task will produce a first-generation interactive application software (expert system) that will allow field elements to routinely apply the strategy in assessing dredged material disposal projects. The software will be especially effective when a data base developed from all or part of previously resolved decisions might apply to an ongoing or upcoming project. The software package will be available in September 1990.

g. Framework for comprehensive analysis of migration pathways (CAMP) in confined disposal facilities (CDF) (FY 89-90). Presently limited guidance exists for evaluating or predicting the containment efficiency for confined disposal of contaminated dredged material. Under this task, the present state of the knowledge will be assessed and a computer-based comprehensive approach and integration mechanism for predicting and evaluating contaminant migration pathways in CDFs will be developed. This framework will present a tiered approach for integrating and assessing physical, chemical, and biological processes. A unifying structure will be provided for CDF assessment and will involve identifying (1) what is known about containment efficiency and contaminant mass transport, (2) key contaminant mobility processes and pathways, and (3) the computational analyses routines needed for quantification and fate of contaminants. A draft CAMP framework will be available in September 1990.

h. Beneficial uses of dredged material: stabilization of dredged material shorelines with wetland vegetation in moderate wave energies (FY 87-89). Numerous Corps disposal sites are located in areas of moderate wave energies. The stability of the shorelines of such sites has been a continuing problem. Although it is expensive, traditional stone armor is often used to protect such sites. The objective of this task is to demonstrate alternative stabilization methods using wetland vegetation. These new techniques should prove as effective as the armor stone in protecting the shoreline with the added benefits of being less costly in addition to providing an environmental enhancement through creating wetland habitat. Field demonstrations have been carried out in Mobile Bay, AL; Mississippi Sound, MS; Galveston Bay, TX; and along the Atlantic Intracoastal Waterway in conjunction with ongoing dredging projects of the Mobile, Galveston, and Wilmington Districts. A number of techniques have been demonstrated, including plant rolls, planting mats, and low-cost and/or portable breakwaters to allow establishment of the vegetation in the moderate energy environment. Final guidance document is scheduled for September 1989.

i. Beneficial uses of dredged material: application in large inland waterways (FY 88-90). Despite frequent economic

benefits of inland aquatic placement, the potential uses of dredged material to create or enrich submerged aquatic habitats have not been systematically examined. This task will not only examine the issue, but will also develop field guidance for future applications of the successful techniques. In conjunction with ongoing District projects, the following demonstrations sites have been examined: (1) a ripple-pool complex in the Tombigbee River near Columbus, MS; (2) a gravel-bar habitat in the lower Ohio River near Mound City, IL; (3) a site near Diamond Island in the Tennessee River; and (4) sites along the Flint-Appalachicola Waterway. Completion of the site-specific studies and publication of the synthesis report will be accomplished in FY 90.

j. Dredged material chemical testing cost reduction (FY 87-89). The cost of testing dredged material is extremely high, especially when the entire list of priority chemicals is analyzed for each sediment sample and numerous samples are tested. Moreover, much of this testing is required by Federal and State regulatory programs without clear demonstration of the need for or intended use of the data. This task is concerned with reducing that cost while providing the basic testing and assessment information for an appropriate evaluation of the environmental impact of dredged material disposal. Areas of interest will include but will not be restricted to (1) limiting the extent of testing through careful initial evaluation, (2) using a tiered approach to testing, (3) implementing efficient sampling plan approaches such as compositing and archiving of samples, and (4) analyzing sediments for a single contaminant that can be related to the distribution of other contaminants. Draft guidance on techniques to reduce chemical testing will be available in September 1989.

k. Guidelines for long-term management strategies (LTMS) of dredged material placement (FY 88-90). A number of federal navigation projects are facing a serious shortage of a dredged material disposal sites, especially upland sites. In many instances the projects rely on cycle-to-cycle identification of a disposal site. This problem can only intensify as less land is available or additional dredged material is removed. To fully and effectively address this long-term problem the Corps has initiated development of Long-Term Management Strategies for placement of dredged material. This task will assist the Corps LTMS steering group in developing, documenting, and disseminating guidance for preparing and implementing appropriate LTMS for dredging projects. The following areas will be pursued: (1) working sessions will be held with various model District study participants, (2) lessons learned and benefits derived from the model demonstrations will be identified and assessed, (3) Corps guidance for developing LTMS will be prepared, and (4) a how-to workshop for all Corps FOAs will be developed for direct technology transfer to interested field elements.

17. Although the dredged material management effort presently consists of the above eleven tasks, it incorporates the knowledge of many years of experience and research and development and can, if the need arises, be modified to address other high-priority needs.

18. Appendix A lists all reports published within the program since 1977.

Current Research

Background

19. The DMRP addressed and answered the critical environmental issues defined in the early 1970s. Subsequent regulatory research efforts under DOTS provided technical information used by the Corps and the USEPA in conducting dredging and placement evaluations required by Federal legislation. Because of the dynamic and evolving nature of environmental considerations and the increasing depth of knowledge of contaminant/ecological relationships neither the DMRP nor the subsequent regulatory research has addressed to the level necessary, all questions on environmental impacts associated with dredging or dredged material placement. Moreover, new questions or concerns are evolving more rapidly than the Corps' existing data base.

20. The need to continue research on the environmental consequences of dredged material placement was stated by the Corps during Congressional hearings in early 1980. The Congress, as a result of testimony received, expressed concern over the long-term environmental effects of dredged material placement in some instances. In addition, international agreements such as the London Dumping Convention (an international treaty) as well as domestic regulations require consideration of chronic or sublethal effects in the evaluation of dredged material placement in the oceans. Presently, the state of the art allows for accurate measurement of bioaccumulation, but does not provide for predicting steady-state bioaccumulation into organisms of chemicals from sediments. In addition, current evaluative protocol regards any bioaccumulation as an adverse impact because cause-and-effect relationships are lacking for interpreting the ecological significance of uptake. Other sublethal effects are not being addressed by the regulatory program because of the lack of state-of-the-art, field-verified procedures. The lack of defined and acceptable testing procedures that allow for an accurate assessment of the

ecological significance of these effects has led to interpretative data conflicts among regulatory agencies and litigation on Federal projects.

21. The Corps also has the responsibility to regulate certain activities impacting wetland functions and values. As a result of this responsibility, wetlands must be defined and delineated and information must be provided for evaluating wetlands.

22. To address the concerns expressed by the Congress and because of the need to establish a sound technical basis for managing highly contaminated dredged material and promulgating the legislatively mandated regulatory mission, the Corps is conducting these programs: LEDO, WRP, a work unit under the IOMT program that addresses methods of dredging contaminated sediments, and the Dredging Research Program (DRP).

Long-term Effects of
Dredging Operations Program

23. The objectives of LEDO are to provide new or improved state-of-the-art technology for predicting long-term environmental impacts of dredging operations and to improve and develop methods for minimizing any adverse impacts associated with dredged material placement. The effects of aquatic and upland placement are currently being researched. LEDO is planned as a continuing program, as applied environmental research must be responsive to the dynamic nature of current pollution problems and research priorities must as a consequence be responsive to these needs.

24. Specific areas of research presently addressed in LEDO include the following:

a. Bioaccumulation (uptake) and biomagnification (transfer) in the aquatic environment including effects interpretation. Establish the significance of bioaccumulation and biomagnification in aquatic organisms of toxic materials associated with the aquatic placement of contaminated dredged material. Develop or improve predictive techniques for estimating the potential bioaccumulation of toxic chemicals from sediment.

b. Development and assessment of procedures to reduce adverse impacts. Perform laboratory and field tests of existing procedures that will eliminate or minimize adverse impacts of dredged material placement. Capping of contaminated dredged material with clean dredged material is an example of an innovative procedure that the London Dumping Convention allows, provided continuing research is conducted.

c. Upland plant and animal bioassay procedures. Improve first-generation plant and animal bioassays for predicting uptake of

contaminants from dredged material in wetland and upland disposal areas.

d. Effluent quality. Increase the understanding of the geochemical changes that occur with time in upland dredged material containment areas; develop or improve techniques for predicting contaminant concentrations in the effluent from diked dredged material containment areas. The development of mixing zone technology is also included in this work.

e. Sediment Geochemistry. Investigate and delineate the factors responsible for the regulation of the bioavailability of contaminants associated with sediment. Determine if contaminant activities measured in sediment affect contaminant bioavailability by examining sublethal toxicity and bioaccumulation.

25. Research results will provide a broadened state-of-the-art technical basis for the Corps' implementation of its environmental regulatory responsibilities under Federal legislation. Additionally, technically updating the Ocean Dumping Implementation Manual and providing a Section 404 Clean Water Act implementation manual are program objectives. Emphasis will be placed on presenting research results in the national and international technical and scientific literature as well as making results immediately available to the field through innovative Corps technology transfer channels.

26. LEDO reports published since 1977 are also listed in Appendix A.

Wetlands Research Program

27. Two main objectives of the WRP are the development of improved and standardized techniques to assist Corps field personnel in the identification and delineation of wetlands and the assessment, and quantification of wetland functions and values. Both objectives are designed primarily to meet the needs of the Section 404 regulatory program; however, their application extends to planning, construction, and operational activities within the Corps. The first objective was essentially completed with the publication of "Corps of Engineers Wetland Delineation Manual" (WES Technical Report Y-87-1). A one-year field review followed with the idea that the manual would be rewritten based on the field input. Subsequent negotiations with the USEPA, Soil Conservation Service (SCS), and US Fish and Wildlife Service resulted in a combined Federal Wetland Delineation Manual; the agreement was signed by representatives of the four agencies on January 10, 1989 and the manual was published in July 1989.

28. The emphasis in the WRP is now on the second objective: the assessment and measurement methodologies for wetland functions and values. Previous WRP research has consisted of evaluating existing assessment techniques, surveying needs, identifying technical data gaps, and completing a nationwide research plan. The research plan identifies and prioritizes Corps wetlands values information needs. The highest priority wetlands research identified in the plan is under way and consists of determining selected physical, chemical, and biological functions in bottomland hardwood forests of the southeastern United States. The primary study area is the Black Swamp area of the Cache River in Arkansas.

29. A major product of the functions and values research is the Wetland Evaluation Technique (WET). WET is a national procedure for identifying the probability that a given wetland can perform separate functions. These functions address different aspects of hydrology, water quality, and fish and wildlife habitat. Research results derived from the Cache River investigation and similar studies will provide specific information needed to field verify, refine, and regionalize WET. Input from the Corps field elements will assist in determining a priority of wetland type by region in subsequent studies.

30. Specific work units in the WRP for FY 89 were as follows:

a. Assessment and measurement methods for functional wetland values. This work unit continues to develop and refine the two-volume Wetland Evaluation Technique (WET). Primary emphasis is to identify data gaps and research needs to improve WET. Other federal agencies are reviewing the functional models in WET and identified changes will be made.

b. Quantification of physical, chemical, and biological values. Functional values in WET are grouped into physical, chemical, and biological values and a work unit exists to address each group of values identified. While the models in WET are presently being evaluated in the previous work unit to strengthen the WET methods and technique, these three work units are investigating specific wetlands on a regional basis. As each study is completed, the information will be incorporated into WET.

c. Quantification of selected economic values. An important aspect of wetland assessment during the public interest review process may include the economic benefits of developing a particular wetland site. Although a permit decision should never be made solely on economic benefits, such information may be considered. However, readily applicable methods for monetary assessment of wetland values are lacking. The objective of this work unit is to obtain information necessary for monetary

assessment of selected wetland functions and values and to develop economic models that are compatible with WET.

31. Two other high-priority work units that are presently unfunded include aspects of wetland mitigation and determination of the cumulative impacts of wetland loss. Research on these work units will begin as funds become available.

32. The Wetlands Research Program also assists in wetland training courses offered by WES to assure that current technical knowledge is being transferred to Corps personnel.

Dredging Contaminated Sediment

33. In the United States, much work has been conducted over the past 15 years on the effects of dredged material placement. However, minimal work has been conducted on the effects of the dredging operation itself because it was assumed that the placement operation would have the most significant impact. However, because of the need to dredge highly contaminated sediment, research was required to identify environmental parameters associated with conventional dredges as well as investigating and developing procedures and equipment to minimize adverse effects associated with the dredging operation. This study was incorporated into the Improvement of Operations and Maintenance Techniques (IOMT) Program, another major program in the Corps of Engineers.

34. Existing data on the resuspension of sediments and contaminants are being collected on a national and international basis. In addition, field studies are being conducted at various sites where unconventional equipment is being used. Based on these data, guidelines will be developed for dredging highly contaminated sediments to minimize any adverse impacts.

Dredging Research Program--technology transfer

35. Finally, the Environmental Laboratory through the EEDP has been tasked with accomplishing the technology transfer efforts of the 7-year, $35 million Dredging Research Program (DRP). The program is managed by the Coastal Engineering Research Center (CERC) of the WES and is a major thrust toward developing improved technologies and equipment that can reduce the cost of dredging operations. The program focuses on problem areas related to the physical aspects of dredging or dredging projects. Corps' needs in terms of research related to the environmental aspects of dredging will continue to be met through activities within the EEDP. As in the EEDP, the DRP will use various media to assure expedient transfer of results and methods to

facilitate their use. Specifically, program results will, as appropriate, be presented in an information exchange bulletin; manuals; specifications; technical reports; technical notes; miscellaneous papers; computer software and user guides; instructional videotapes; lectured training courses, meetings, workshops, and symposia; and one-stop consultations by the Program Manager and Principal Investigators.

Summary

36. Prior to the 1970s, little research was conducted by the Corps of Engineers, or by other agencies, on the environmental effects of dredging and dredged material placement. Within the past 15 years, major research has been conducted and is continuing in high-priority areas. The Corps has a three-element (research, assistance, and management) approach to better understanding the environmental impacts of dredging operations and the regulatory aspects of wetlands. Research is conducted under LEDO and the WRP. Through DOTS, direct field assistance is available and a dredged material management program places the research developed in a user-oriented framework. The Corps of Engineers has, through the EEDP, an innovative and active technology transfer program through the mechanism of providing direct technical assistance to the field, and a means to address high-priority research needs on a continuing basis.

Appendix A: Reports Published by the Environmental Effects of Dredging Programs

1977

EPA/CE

Environmental Protection Agency/Corps of Engineers Technical Committee on Criteria for Dredged and Fill Material. "Ecological Evaluation of Proposed Discharge of Dredged Material into Ocean Waters; Implementation Manual for Section 103 of Public Law 92-532 (Marine Protection, Research, and Sanctuaries Act of 1972)," July 1977 (Second Printing: April 1978), US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A143 776.

1980

Technical Reports

* Perrier, E. R., Llopis, J. L., and Spaine, P. A. 1980. "Area Strip Mine Reclamation Using Dredged Material: A Field Demonstration," Technical Report EL-80-4, US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A088 612.

* Harrison, W., and Luik, A. V. 1980. "Suitability of Dredged Material for Reclamation of Surface-Mined Land, Ottawa, Illinois, Demonstration Project," Technical Report EL-80-7, Argonne National Laboratory, Argonne, Illinois, prepared for US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A088 586.

* Morrison, R., Stearns, R., and Chen, K. Y. 1980. "Effects of Upland Disposal of Dredged Material on Groundwater Quality," Technical Report EL-80-8, University of Southern California at Los Angeles, prepared for US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A099 300.

Miscellaneous Paper

* Peddicord, R., Tatem, H., Gibson, A., and Pedron, S. 1980. "Biological Assessment of Upper Mississippi River Sediments," Miscellaneous Paper EL-80-5, US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A094 248.

---

* Out-of-print report. Copies can be purchased from the National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, VA 22161.

1981

Technical Reports

* Pequegnat, W. E., Pequegnat, L. H., James, B. M., Kennedy, E. A., Fay, R. R., and Fredericks, A. D. 1981. "Procedural Guide for Designation Surveys of Ocean Dredged Material Disposal Sites," Technical Report EL-81-1, TerEco Corporation, College Station, TX, prepared for US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A096 955.

* Hammer, D. P. 1981. "Evaluation of Underdrainage Techniques for the Densification of Fine-Grained Dredged Material," Technical Report EL-81-3, US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A099 336.

* Simmers, J. W., Folsom, B. L., Jr., Lee, C. R., and Bates, D. J. 1981. "Field Survey of Heavy Metal Uptake by Naturally Occurring Saltwater and Freshwater Marsh Plants," Technical Report EL-81-5, US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A101 662.

* Fowler, J. 1981. "Design, Construction, and Analysis of Fabric-Reinforced Embankment Test Section at Pinto Pass, Mobile, Alabama," Technical Report EL-81-7, US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A107 556.

* Shuba, P. J., Petrocelli, S. R., and Bentley, R. E. 1981. "Considerations in Selecting Bioassay Organisms for Determining the Potential Environmental Impact of Dredged Material," Technical Report EL-81-8, EG&G International, Inc., Pensacola, FL, and Wareham, MA, prepared for US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A105 246.

* Palermo, M. R., Shields, F. D., and Hayes, D. F. 1981. "Development of a Management Plan for Craney Island Disposal Areas," Technical Report EL-81-11, US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A111 440.

* Folsom, B. L., Jr., Lee, C. R., and Bates, D. J. 1981. "Influence of Disposal Environment on Availability and Plant Uptake of Heavy Metals in Dredged Material," Technical Report EL-81-12, US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A112 279.

Miscellaneous Papers

* Folsom, B. L., Jr., Lee, C. R., and Preston, K. M. 1981. "Plant Bioassay of Materials from the Blue River Dredging Project," Miscellaneous Paper EL-81-6, US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A104 986.

EPA/CE

Plumb, R. H., Jr. 1981. "Procedures for Handling and Chemical Analysis of Sediment and Water Samples," Technical Report EPA/CE-81-1, prepared by the Great Lakes Laboratory, State University College at Buffalo, Buffalo, NY, for the US Environmental Protection Agency/Corps of Engineers Technical Committee on Criteria for Dredged and Fill Material, published by US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A103 788.

1982

Miscellaneous Paper

* Landin, M. C., ed. 1982. "Habitat Development at Eight Corps of Engineers Sites: Feasibility and Assessment," Miscellaneous Paper D-82-1, US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A112 662.

Related Report

Water Resources Support Center. 1982. "Management of Bottom Sediments Containing Toxic Substances," *Proceedings of the 6th U. S./Japan Experts Meeting*, published for the US Army Corps of Engineers Water Resources Support Center, Fort Belvoir, VA, by the US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A116 778.

1983

Technical Reports

Cargill, K. W. 1983. "Procedures for Prediction of Consolidation in Soft Fine-Grained Dredged Material," Technical Report D-83-1, US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A125 320.

* Schroeder, P. R. 1983. "Chemical Clarification Methods for Confined Dredged Material Disposal," Technical Report D-83-2, US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A134 731.

* O'Connor, J. M., and O'Connor, S. G. 1983. "Evaluation of the 1980 Capping Operations at the Experimental Mud Dump Site, New York Bight Apex," Technical Report D-83-3, prepared by the New York University Medical Center, Tuxedo Park, NY, and The Valley Ecosystems, Warwick, NY, for the US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A138 435.

Rubenstein, N. I., Lores, E., and Gregory, N. 1983. "Accumulation of PCBs, Mercury, and Cadmium by *Nereis virens*, *Mercenaria mercenaria*, and *Palaemonetes pugio* from Contaminated Harbor Sediments," Technical Report D-83-4, prepared by US Environmental Protection Agency, Environmental Research Laboratory, Gulf Breeze, FL, for the US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A136 856.

Miscellaneous Papers

van Driel, W., Smilde, K. W., and van Luit, B. 1985. "Comparison of the Heavy-Metal Uptake of *Cyperus 8* and of Agronomic Plants Grown on Contaminated Dutch Sediments," Miscellaneous Paper D-83-1, Institute for Soil Fertility, 8, The Netherlands, prepared for the US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A158 216.

Homziak, J., and Lunz, J. D. 1983. "Aquaculture in Dredged Material Containment Areas," Miscellaneous Paper D-83-2, US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A135 075.

Related Report

* Water Resources Support Center. 1983. "Management of Bottom Sediments Containing Toxic Substances," *Proceedings of the 7th U. S./Japan Experts Meeting*, published for the US Army Corps of Engineers Water Resources Support Center, Fort Belvoir, VA, by the US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A136 740.

1984

Technical Reports

* Brannon, J. M. 1984. "Transformation, Fixation, and Mobilization of Arsenic and Antimony in Contaminated Sediments," Technical Report D-84-1, US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A139 032.

* Dillon, T. M. 1984. "Biological Consequences of Bioaccumulation in Aquatic Animals: An Assessment of the Current Literature," Technical Report D-84-2, US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A144 161.

* Salamon, K. J. 1984. "Long-Term Impact of Dredged Material Disposal in Lake Erie Off Ashtabula, Ohio," Technical Report D-84-3, Roy F. Weston, Inc., Weston Way, West Chester, PA, prepared for US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A146 720.

* Dexter, R. N., Anderson, D. E., and Quinlan, E. A. 1984. "Long-Term Impacts Induced by Disposal of Contaminated River Sediments in Elliott Bay, Seattle, Washington," Technical Report D-84-4, URS Company, Seattle, WA, prepared for the US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A148 815.

Tatem, H. E. 1984. "Long-Term Impact of Dredged Material at Two Open-Water Sites: Lake Erie and Elliott Bay; Evaluative Summary," Technical Report D-84-5, US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A152 029.

* Rubinstein, N. I., Gilliam, W. T., and Gregory, N. R. 1984. "Dietary Accumulation of PCB's From a Contaminated Sediment Source by a Demersal Fish Species (*Leiostomus xanthurus*)," Technical Report D-84-6, Environmental Research Laboratory, Gulf Breeze, FL, prepared for the US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A149 415.

Kay, S. H. 1984. "Potential for Biomagnification of Contaminants within Marine and Freshwater Food Webs," Technical Report D-84-7, US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A150 747.

Instruction Reports

Sheng, P. Y. 1984. "Preliminary User's Manual 3-D Mathematical Model of Coastal, Estuarine, and Lake Currents (CELC3D)," Instruction Report D-84-1, US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A142 070.

Related Reports

* Patin, T. R. 1984. "Management of Bottom Sediments Containing Toxic Substances," *Proceedings of the 8th U. S./Japan Experts Meeting*, published for the US Army Corps of Engineers Water Resources Support Center, Fort Belvoir, VA, by the US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A149 291.

* Raymond, G. L. 1984. "Techniques to Reduce the Sediment Resuspension Caused by Dredging," Miscellaneous Paper HL-84-3, US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A146 898.

* Richardson, T. W. 1984. "Agitation Dredging: Lessons and Guidelines from Past Projects," Technical Report HL-84-6, US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A150 146.

* Hignett, H. J. 1984. "The Current State of the Art of Rock Cutting and Dredging," Miscellaneous Paper GL-84-17, Camborne School of Mines, Cornwall, United Kingdom, for the US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A150 500.

Internal Working Documents

McFarland, V. A., and Peddicord, R. K. 1984. "Assessment of Potential Bioaccumulation from Toledo and Toronto Harbor Sediments," Internal Working Document D-84-1, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Poindexter, M. E. 1984. "Design of Settlement Plates for the Duwamish Waterway Capping Demonstration Project," Internal Working Document D-84-3, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Miscellaneous Paper

* Rubinstein, N. I., Gilliam, W. T., and Gregory, N. R. 1984. "Evaluation of Three Fish Species as Bioassay Organisms for Dredged Material Testing," Miscellaneous Paper D-84-1, Environmental Research Laboratory, US Environmental Protection Agency, Sabine Island, Gulf Breeze, FL, and Department of Biology, Georgia State University, Atlanta, GA, for the US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A153 983.

1985

Technical Reports

Pesch, G. G., Mueller, C., Pesch, C. E., Heltshe, J., and Schauer, P. S. 1985. "Application of Sister Chromatid Exchange in Marine Polychaetes to Black Rock Harbor Sediment, Laboratory Documentation Phase," Technical Report D-85-1, US Environmental Protection Agency, Narragansett, RI, prepared for US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A157 372.

Lake, J., Hoffman, G. L., and Schimmel, S. C. 1985. "Bioaccumulation of Contaminants from Black Rock Harbor Dredged Material By Mussels and Polychaetes," Technical Report D-85-2, US Environmental Protection Agency, Narragansett, RI, prepared for US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A157 365.

Zaroogian, G. E., Pesch, C., Schauer, P., and Black, D. 1985. "Laboratory Evaluation of Adenylate Energy Charge as a Test for Stress in *Mytilus Edulis* and *Nephtys Incisa* Treated with "Dredged Material," Technical Report D-85-3, US Environmental Protection Agency, Narragansett, RI, prepared for US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A157 374.

* Cargill, K. W. 1985. "Mathematical Model of the Consolidation/Desiccation Processes in Dredged Material," Technical Report D-85-4, US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A158 730.

* Newling, C. J., and Landin, M. C. 1985. "Long-Term Monitoring of Habitat Development at Upland and Wetland Dredged Material Disposal Sites, 1974-1982," Technical Report D-85-5, US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A159 106.

* Nelson, W. G., Black, D., and Phelps, D. 1985. "Utility of the Scope for Growth Index to Assess the Physiological Impact of Black Rock Harbor Suspended Sediment on the Blue Mussel, *Mytilus Edulis:* A Laboratory Evaluation," Technical Report D-85-6, US Environmental Protection Agency, Narragansett, RI, prepared for US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A161 056.

* Johns, D. M., Gutjahr-Gobell, R., and Schauer, P. 1985. "Use of Bioenergetics to Investigate the Impact of Dredged Material on Benthic Species: A Laboratory Study With Polychaetes and Black Rock Harbor Material," Technical Report D-85-7, Edgerton Research Laboratory, Boston, MA, and US Environmental Protection Agency, Narragansett, RI, prepared for US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A161 050.

Gentile, J. H., et al. 1985. "Application of Laboratory Population Responses for Evaluating the Effects of Dredged Material," Technical Report D-85-8, US Environmental Protection Agency, Narragansett, RI, prepared for US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A160 507.

* Rogerson, P. F., Schimmel, S. C., and Hoffman, G. 1985. "Chemical and Biological Characterization of Black Rock Harbor Dredged Material," Technical Report D-85-9, US Environmental Protection Agency, Narragansett, RI, prepared for US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A164 065.

Brannon, J. M., et al. 1985. "Effectiveness of Capping in Isolating Contaminated Dredged Material from Biota and the Overlying Water," Technical Report D-85-10, US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A165 251.

Related Reports

Patin, T. R. 1985. "Management of Bottom Sediments Containing Toxic Substances," *Proceedings of the 9th U. S./Japan Experts Meeting*, published for the US Army Corps of Engineers Water Resources Support Center, Fort Belvoir, VA, by the US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A157 863.

Patin, T. R. 1985. "Management of Bottom Sediments Containing Toxic Substances," *Proceedings of the 10th U. S./Japan Experts Meeting*, published for the US Army Corps of Engineers Water Resources Support Center, Fort Belvoir, VA, by the US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A163 709.

Miscellaneous Papers

Francingues, N. R., Jr., Palermo, M. R., Lee, C. R., and Peddicord, R. K. 1985. "Management Strategy for Disposal of Dredged Material: Contaminant Testing and Controls," Miscellaneous Paper D-85-1, US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A158 406.

* Dillon, T. M., and Gibson, A. B. 1985. "Bioaccumulation and Effects on Reproduction in Aquatic Organisms: An Assessment of the Current Literature," Miscellaneous Paper D-85-2, US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A156 774.

Technical Reports

* Yevich, P. P., et al. 1986. "Histopathological Effects of Black Rock Harbor Dredged Material on Marine Organisms, A Laboratory Investigation," Technical Report D-86-1, Environmental Research Laboratory, Narragansett, RI, prepared for the Environmental Laboratory, US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A168 126.

Truitt, C. L. 1986. "The Duwamish Waterway Capping Demonstration Project: Engineering Analysis and Results of Physical Monitoring," Technical Report D-86-2, US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A168 169.

* Parnell, J. F., DuMond, D. M., and McCrimmon, D. A. 1986. "Colonial Waterbird Habitats and Nesting Populations in North Carolina Estuaries: 1983 Survey," Technical Report D-86-3, University of North Carolina at Wilmington, Wilmington, NC, and Point Reyes Observatory, Stinson Beach, CA, prepared for US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A171 626.

* Palermo, M. R. 1986. "Development of a Modified Elutriate Test for Estimating the Quality of Effluent from Confined Dredged Material Disposal Areas," Technical Report D-86-4, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Miscellaneous Papers

Palermo, M. 1986. "Interim Guidance for Predicting the Quality of Effluent Discharged from Confined Dredged Material Disposal Areas," Miscellaneous Paper D-86-1, US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A168 140.

Brannon, J., et al. 1986. "Effectiveness of Capping in Isolating Dutch Kills Sediment from Biota and the Overlying Water," Miscellaneous Paper D-86-2, US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS NO. AD A170 381.

* Pennington, J. C. 1986. "Feasibility of Using Mycorrhizal Fungi Enhancement of Plant Establishment on Dredged Material Disposal Sites: A Literature Review," Miscellaneous Paper D-86-3, US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A170 443.

* Pranger, S. A., and Schroeder, P. R. 1986. "Dye Tracer Studies at the Kenosha, Manitowoc, Milwaukee, and Kewaunee Harbors Confined Disposal Facilities," Miscellaneous Paper D-86-4, US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A172 170.

* McFarland, V. A., Clark, J. U., and Gibson, A. B. 1986. "Changing Concepts and Improved Methods for Evaluating the Importance of PCBs as Dredged Sediment Contaminants," Miscellaneous Paper D-86-5, US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A174 177.

Sanderson, W. H., and McKnight, A. L. 1986. "Survey of Equipment and Construction Techniques for Capping Dredged Material," Miscellaneous Paper D-86-6, The Sand Hen Corporation, Wilmington, NC, prepared for US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A174 650.

Sanders, D. R., Sr., et al. 1986. "Wetlands Investigations on Akers Ranch in Big Valley, California," Miscellaneous Paper D-86-7, US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A177 297.

1987

Technical Reports

* Environmental Laboratory. 1986. "Beneficial Uses of Dredged Material; Proceedings of the First Interagency Workshop, 7-9 October 1986, Pensacola, Florida," Technical Report D-87-1, US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A179 956.

* Shields, F. D., et al. 1987. "Design and Management of Dredged Material Containment Areas to Improve Hydraulic Performance," Technical Report D-87-2, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

* Gentile, J. H., et al. 1987. "The Assessment of Black Rock Harbor Dredged Material Impacts on Laboratory Population Responses," Technical Report D-87-3, US Environmental Protection Agency, Narragansett, RI, prepared for US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A184 509.

* Scott, J., et al. 1987. "Impact of Open-Water Disposal of Black Rock Harbor Dredged Material on Benthic Recolonization at the FVP Site," Technical Report D-87-4, US Environmental Protection Agency, Narragansett, RI, prepared for US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A184 166.

* Pesch, G. G., et al. "Sister Chromatid Exchange in Marine Polychaetes Exposed to Black Rock Harbor Sediment," Technical Report D-87-5, US Environmental Protection Agency, Narragansett, RI, prepared for US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A184 570.

Lake, J. L., Galloway, W., Hoffman, G., Nelson, W., and Scott, J. 1988. "Comparison of Field and Laboratory Bioaccumulation of Organic and Inorganic Contaminants from Black Rock Harbor Dredged Material," Technical Report D-87-6, US Environmental Protection Agency, Narragansett, RI, and Science Application International Corporation, Narragansett, RI, prepared for the US Army Engineer Waterways Experiment Station, Vicksburg, MS.

* Nelson, W. G., et al. 1987. "Effects of Black Rock Harbor Dredged Material on the Scope for Growth of the Blue Mussel, *Mytilus edulis*, after Laboratory and Field Exposures," Technical Report D-87-7, US Environmental Protection Agency, Narragansett, RI, prepared for US Army Engineer Waterways Experiment Station, Vicksburg, MS.

* Yevich, P. R., et al. 1987. "Effects of Black Rock Harbor Dredged Material on the Histopathology of the Blue Mussel *Mytilus edulis* and Polychaete Worm *Nephtys incisa* after Laboratory and Field Exposures," Technical Report D-87-8, US Environmental Protection Agency, Narragansett, RI; and Science Applications International Corporation, Narragansett, RI, prepared for US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Miscellaneous Papers

* Skogerboe, J. G., et al. 1987. "Prediction of Surface Runoff Water Quality From Black Rock Harbor Dredged Material Placed in an Upland Disposal Site," Miscellaneous Paper D-87-1, US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A182 235.

Gunnison, D., et al. 1987. "Development of a Simplified Column Test for Evaluation of Thickness of Capping Material Required to Isolate Contaminated Dredged Material," Miscellaneous Paper D-87-2, US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A179 929.

* Clarke, J. U., and Gibson, A. B. 1987. "Regulatory Identification of Petroleum Hydrocarbons in Dredged Material; Proceedings of a Workshop," Miscellaneous Paper D-87-3, US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A180 082.

Related Reports

Patin, T. R. 1987. "Management of Bottom Sediments Containing Toxic Substances," *Proceedings of the 11th U. S./Japan Experts Meeting*, published for the US Army Corps of Engineers Water Resources Support Center, Fort Belvoir, VA, by the US Army Engineer Waterways Experiment Station, Vicksburg, MS.

* Water Resources Support Center. 1987. "Third United States-The Netherlands Meeting on Dredging and Related Technology, 10-14 September 1984, Charleston, South Carolina," published for the US Army Corps of Engineers Water Resources Support Center, Fort Belvoir, VA, by the US Army Engineer Waterways Experiment Station, Vicksburg, MS.

1988

Miscellaneous Papers

* Hill, D. O., Myers, T. E., and Brannon, J. M. 1988. "Development and Application of Techniques for Predicting Leachate Quality in Confined Disposal Facilities; Background and Theory," Miscellaneous Paper D-88-1, US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A190 518.

* Engler, R. M., Patin, T. R., and Theriot, R. F. 1988. "The Corps' Environmental Effects of Dredging Programs," Miscellaneous Paper D-88-2, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

* Walski, T. M., and Schaefer, T. E., Jr. 1988. "Planning-Level Cost Estimates of Dredged Material Containment Islands in New York Harbor," Miscellaneous Paper D-88-3, US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A194 812.

Miller-Way, C. A., and Nelson, D. 1988. "Preliminary Investigation of the Short-Term Effects of Storms on Sedimentary Characteristics and the Nearshore Fauna Using the Sediment Profiling Camera System," Miscellaneous Paper D-88-4, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Bowen, P. R., and Marsh, G. A. 1988. "Benthic Faunal Colonization of an Offshore Borrow Pit in Southeastern Florida," Miscellaneous Paper D-88-5, Florida Atlantic University, Boca Raton, FL, prepared for US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Technical Reports

* Palermo, M. R. 1988. "Field Evaluations of the Quality of Effluent from Confined Dredged Material Disposal Areas," Technical Report D-88-1, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

* Averett, D. E., Palermo, M. R., and Wade, R. 1988. "Verification of Procedures for Designing Dredged Material Containment Areas for Solids Retention," Technical Report D-88-2, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

* Johns, D. M., and Gutjahr-Gobell, R. 1988. "Bioenergetic Effects of Black Rock Harbor Dredged Material on the Polychaete *Nephtys incisa*: A Field Verification," Technical Report D-88-3, prepared by the US Environmental Protection Agency, Narragansett, RI, for the US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A194 228.

Zaroogian, G. E., Rogerson, P. F., Hoffman, G., Johnson, M., Johns, D. M., and Nelson, W. G. 1988. "A Field and Laboratory Study Using Adenylate Energy Charge as an Indicator of Stress in *Mytilus edulis* and *Nephyts incisa* Treated with Dredged Material," Technical Report D-88-4, US Environmental Protection Agency, Narragansett, RI; Tetra Tech, Bellevue, WA and Science Applications International Corporation, Narragansett, RI, prepared for US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A198 107.

Gentile, J. H., et al. 1988. "Synthesis of Research Results: Applicability and Field Verification of Predictive Methodologies for Aquatic Dredged Material Disposal," Technical Report D-88-5, US Environmental Protection Agency, Narragansett, RI, prepared for US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Peddicord, R. K. 1988. "Summary of the US Army Corps of Engineers/ US Environmental Protection Agency Field Verification Program," Technical Report D-88-6, Battelle Ocean Sciences, Duxbury, MA, prepared for US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Folsom, B. L., Jr., Skogerboe, J. G., Palermo, M. R., Simmers, J. W., Pranger, S. A., and Shafer, R. A. 1988. "Synthesis of the Results of the Field Verification Program Upland Disposal Alternative," Technical Report D-88-7, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Landin, M. C., ed. 1988. "Inland Waterways: Proceedings of a National Workshop on the Beneficial Uses of Dredged Material, 27-30 October 1987, St. Paul, Minnesota," Technical Report D-88-8, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Palermo, M. R., and Thackston, E. L. 1988. "Refinement of Column Settling Test Procedures for Estimating the Quality of Effluent from Confined Dredged Material Disposal Areas," Technical Report D-88-9, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Related Reports

Cofrancesco, A. F., Jr., and Flosi, J. W. 1988. "Evaluation of Products for Control of Mosquitoes at Disposal Sites in the Galveston District," Technical Report EL-88-3, US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A192 448.

Ludwig, D. D., Sherrard, J. H., and Amende, R. A. 1988. "An Evaluation of the Standard Elutriate Test as an Estimator of Contaminant Release at the Point of Dredging," Contract Report HL-88-1, Virginia Polytechnic Institute, Blackburg and Fort Benjamin Harrison, Indianapolis, IN, prepared for US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A198 542.

Landin, M., ed. 1988. "The Beneficial Uses of Dredged Material: Proceedings of the North Atlantic Regional Conference, 12-14 May 1987, Baltimore, Maryland," US Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A192 350.

1989

Miscellaneous Papers

Brannon, J. M., Gunnison, D., Averett, D. E., Martin, J. L., and Chen, R. L. 1989. "Analyses of Impacts of Bottom Sediments from Grand Calumet River and Indiana Harbor Canal on Water Quality," Miscellaneous Paper D-89-1, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Clarke, J. U., McFarland, V. A., and Pierce, B. D. 1989. "Preliminary Recommendations for a Congener-Specific PCB Analysis in Regulatory Evaluation of Dredged Material," Miscellaneous Paper D-89-2, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Technical Reports

Simmers, J. W., Rhett, R. G., Kay, S. H., Folsom, B. L., Jr. 1989. "Synthesis of the Results of the Field Verification Program Wetland Disposal Alternative," Technical Report D-89-2, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Related Reports

McLellan, T. N., Havis, R. N., Hayes, D. F., and Raymond, G. L. 1989. "Field Studies of Sediment Resuspension Characteristics of Selected Dredges," Technical Report HL-89-9, US Army Engineer Waterways Experiment Station, Vicksburg, MS.